

## CHAPTER 12. ADMINISTRATION

### INTRODUCTION

The design, application, and maintenance of an effective roadway delineation system requires a thorough knowledge of drivers' needs. General concerns are important, as well as those dictated by the geometry and traffic characteristics of the particular roadway. Standards, warrants, and legal implications of the agency's responsibility to maintain the highway in a reasonably safe condition make administration of a safe delineation system difficult. The task is made more complex by the array of delineation techniques and technologies. If liability is to be avoided, the best method must be selected for a particular situation. It is often difficult to determine the level of visibility for delineation that will be adequate for all drivers' needs on a specific roadway.

If funds were unlimited, it would be relatively easy to maintain safe roadways. Technology can meet the challenge, highway agencies have the skills they need, and research is continual and the state of the art always improves. Unfortunately, funds are not unlimited. In reality, cost-effectiveness of delineation alternatives is as important as overall performance. A delicate balance exists between the need for overall frugality and the use of extreme measures where they are needed. Consequently, the role of administration and management becomes more demanding and complex.

This chapter focuses on some of the administrative considerations associated with roadway delineation. These include the implication of legal responsibilities, the availability of Federal funding, cost-saving

procurement practices, the use of highway agency forces versus contracted work, and special treatments associated with the field of delineation.

### LEGAL CONSIDERATIONS

In the past, government entities were all but immune from lawsuits on the theory of "sovereign immunity," derived from English common law. Under the sovereign immunity doctrine, a government entity may be sued only if it consents to the suit in advance. During the past 30 to 40 years, this situation has changed dramatically. Sovereign immunity has now been eroded though the actions of courts and/or legislatures. Consequently, many State highway agencies have become vulnerable to lawsuits for damages resulting from highway accidents.

Because of these changes in legal doctrine, highway agencies' personnel increasingly are involved in a field of litigation that was previously of concern only to attorneys. Today, it is necessary that State and local highway agency staffs keep abreast of current highway law practices. Accordingly, the basic legal considerations involved in roadway delineation practices have been included here to provide a basic understanding of the purpose, intent, and direction of current tort liability.

This discussion is a basic treatment of a complex subject. It is not meant to interpret the law or establish guidelines. It is intended only to help highway agencies recognize the possible consequences of failure to maintain and safeguard their roadways.

There are numerous reports and references prepared by legal staffs that can be consulted for more definitive information. The Institute of Transportation Engineers has developed a one-day seminar as part of its Continuing Education Program entitled *Traffic Improvements-Legal Aspects and Liability*. It is intended to upgrade and expand awareness among highway agencies' personnel.<sup>(93)</sup> In addition, the legal staffs of State agencies often are called upon by operating units to interpret the statutes that concern them and suggest ways to avoid tort litigation.

### **Definition of Tort Liability**

The legal responsibilities of highway agencies arise from the principles of tort law. This section defines some basic terms.

A *tort* is a "civil wrong, other than breach of contract, for which a court of law will provide a remedy in the form of an action for money damages."<sup>(94)</sup> Torts can be either intentional (assault and battery, false imprisonment, trespass, and theft) or unintentional (negligence). Torts claiming negligence are the most common to highway agencies.

*Liability* means the legal obligation of the tort-feasor (the negligent party) to pay damages to the victim. More than one person or organization may be liable for damages arising out of the same event. In the case of negligent conduct by an employee, both the employee and the employer may be held liable for damage, even when the employer is a public entity.

*Negligence* is defined as the failure to do something that a reasonable person would ordinarily do, or the doing of something that a reasonably prudent person would not do. Negligent conduct creates risk of harm to someone who is owed a duty of exercising care.

*Comparative negligence* is a modern alteration of the strict contributory

negligence rule that bars recovery by negligent plaintiffs. Under the modern system, the defendant is liable for that portion of the damages that his or her own negligence caused. Thus, if an accident is judged to be 40 percent plaintiffs negligence and 60 percent defendant's negligence, and the plaintiff suffered \$10,000 damages, the plaintiff would receive from the defendant \$10,000 less 40 percent, or \$6,000 total. In a jurisdiction that has not adopted the comparative negligence procedure, the plaintiff would recover nothing. The plaintiffs contributory negligence (in any proportion) prevents his or her collection of any damages.

The *reasonable person* (sometimes called the "reasonable man," the "reasonably prudent person," or the "ordinary man") is used to establish the level of care that is judged to be negligent. In effect, this definition imposes a test of negligence as being the "failure to use ordinary care." This is the test most often used in determining liability. In the context of this Handbook, an engineer would be found negligent if his or her conduct did not measure up to that of a hypothetical engineer who acts in a reasonably prudent and careful manner under the same circumstances.

*Duty* in tort law is an obligation to conduct oneself in a way that will protect others from unreasonable risks. Negligence is a breach of the duty to exercise reasonable care owed to those persons to which the duty applies. In this context, a highway agency owes a duty to all drivers on its roadways. The highway agency's duty is to avoid creating unreasonable risks for drivers and to meet the standard of care imposed on that particular highway agency.

The *standard of care* for any person is set by a multitude of factors. At the bare minimum, all persons are required to avoid the creation of unreasonable risks, where feasible. In addition, statutes and regulations help define the standard of care by

which conduct is judged. For example, failing to observe a Stop sign is not only an infraction, but also failure to meet the standard of care that sets the boundaries of liability. Violation of a safety statute is considered to be negligence in itself.

Finally the accepted standards and practices of a profession, trade, or industry also define the standard of care by which conduct is judged. Included in the definition of “accepted standards and practices” is the *Manual on Uniform Traffic Control Devices (MUTCD)*<sup>(1)</sup> and other similar documents. In general, “a violation of a uniform law or regulation may be evidence of negligence or may constitute negligence per se.”<sup>(86)</sup> In the Highway Safety Act of 1966, the *MUTCD* was adopted as a national engineering standard. Although it is a Federal regulation, not a statute, the *MUTCD* standards have been adopted by many States into their own laws, thereby giving them the full force of statutes. A failure by highway agency personnel to conform with the requirements of the *MUTCD* would probably be sufficient to establish negligence (and therefore liability), if an accident results from that failure to conform.

To place these concepts in perspective, it is necessary to recognize several characteristics of tort liability. First, the most common tort is negligence, which is the failure to use reasonable care in one’s actions. Next, court decisions in tort claims are based on the concept of the existence of a “reasonably prudent person” exercising “ordinary care.” Finally, negligence is established by a failure to meet the standard of conduct set by the hypothetical “reasonable person” exercising “ordinary care.”

In effect, the injured plaintiff bringing suit must prove the following in a negligence case arising from a highway accident:

- The defendant (highway agency or its agents) had a legal duty to exercise

reasonable care toward the plaintiff (victim).

- The defendant was negligent (defendant’s conduct failed to meet the standard of reasonable, ordinary care), thus breaching that duty.
- The plaintiff’s damages (injuries, property damage, pain and suffering, or loss of income) were caused by the breach (defendant’s negligence), and were the foreseeable result of that breach.
- The plaintiff must not have been contributorily negligent to recover all the damages suffered.

### Legal Duty and Liability

Highway agency personnel have definite obligations to the public. These duties are imposed specifically or generally by law. Basically, their duty is to maintain the roadway in a reasonably safe condition. This involves inspection, anticipation of defects, and conformity with generally accepted standards and practices. There is no requirement for perfect conditions of repair or for actions beyond the limits of human ingenuity.

To understand the application of the concepts of legal duty, it is necessary to recognize the distinctions between discretionary acts and nondiscretionary (ministerial) acts. Many States that no longer retain the sovereign immunity doctrine have enacted Tort Claims Acts, which prescribe the conditions under which States, their agencies, and their employees may be held accountable for their torts. These acts include some exemption from liability during the performance of so-called discretionary activities.

The term *discretionary* refers to making a choice from a number of alternatives; it requires consideration and independent judgment to choose a course of action. On

the other hand, *ministerial* duties involve mandatory tasks that require little personal judgment. The difference between discretionary and ministerial functions is very important in tort claims against public entities. In general, a public entity and its employees are not liable for negligence in the performance of discretionary activities. However, the courts constantly revise the law in this area. Classification of an activity as either discretionary or ministerial is subject to constantly shifting legal interpretations.

Also, the limited exemptions from liability for discretionary activities do not provide absolute protection from legal liability. If discretion is abused, courts may substitute their own discretion for that of the defendant to reach a result in a particular case.

The courts normally consider the design of roadways to be a discretionary government function, since it involves high-level planning activity and evaluation of policies, competing alternatives, and other factors. Many decisions support this, holding that design is quasi-legislative in character and must be protected from the “second guessing” of inexperienced courts. Unless there is an abuse of discretion that justifies a court resorting to second guessing, most roadway design issues remain within the control of highway agency personnel. To help protect State highway agencies and employees from tort liability, some legislatures have passed design immunity statutes. Designs that have been properly approved are further isolated from possible tort claims.

### **Notice of Defect**

The highway agency has a duty to correct a dangerous condition when it receives notice of the hazard. Most courts say the State must have had notice of the hazard for a sufficient time to afford them a reasonable opportunity to repair the condition or take precautions against the

danger. When a dangerous condition is the result of the State’s own negligence, the notice requirement does not apply. The State does not need notice of faulty construction, maintenance, or repair of its roadways, because the State should know its own actions. However, if the danger did not result from the active negligence of the public entity, it must perform repairs once it has notice of the defect.

Statutes may require that a highway agency have notice of the condition for a specified period of time. If the notice period is five days, and an accident is caused by a defect that originated the same day of the accident, the statutory notice period would not be satisfied and the highway agency would not have had a reasonable opportunity to make repairs. The notice must be of the particular defect that caused the accident, not merely of conditions that may produce the defect. In this example, the statutory period may be considered satisfied if the State had knowledge of the unsafe condition.

Finally, it is possible that a condition has existed for such a time and is of such a nature that the State should have discovered the condition by reasonable diligence. In this case, the notice is said to be constructive, and the State’s knowledge of the condition is implied. The courts may consider whether the defect was difficult to discover. That is, the court will consider the nature of the defect, its location and duration, the amount of use the roadway receives, and whether the defect would easily be perceived. This will aid the court in deciding if the State had reasonable notice.

### **Maintenance of Delineation Systems**

The wording of *MUTCD* suggests some of the legal implications of delineation maintenance. Only the Interstate system is required to have delineation markings (by use of the word *shall*). In most cases, the *MUTCD* does not specifically state that

markings are required. It appears to leave the decision to the discretion of the individual highway agencies.

The duties of highway agencies with regard to pavement markings are summarized as follows:

- "In the absence of a statute, it has been held that there is no general duty of a State or other governmental unit to install or provide highway signs, lights, or markings."
- "However, the duty to provide warnings, lights, or markings may arise where the particular highway presents an unusual, dangerous condition,"
- "Although there may be no duty to install warnings, signals, or markings in the first instance, once installed, there is a duty to maintain them in good serviceable condition."<sup>(95)</sup>

### Implications of Tort Liability

Civil litigation suits, especially tort law cases, have increased dramatically in the last decade. This is a logical result of the trend toward large awards to litigants. The June 6, 1977, issue of *Business Week* noted that Federal court civil cases have increased 84 percent in the last ten years. A February 20, 1978, article in *TIME* is quoted as saying that the first million-dollar tort judgement was awarded in 1962, with 59 more from 1962 to 1972. Another 145 such judgments were recorded in the five-year period from 1972 to 1977. These facts, coupled with the erosion of sovereign immunity for governmental agencies, pose critical problems for highway departments. The State of California has experienced this.

The State of California lost its sovereign immunity in a 1961 ruling of the State supreme court. At that time, there was one full-time attorney assigned to handle damage claims for the Department of Transportation (Caltrans). In the year

1960-61, there were 193 claims totaling \$10 million. These claims increased following approval of the California Tort Claims Act in 1963. By 1976, Caltrans employed 40 full-time attorneys and 18 full-time investigators. In early 1978, Caltrans had 65 attorneys assigned to handle the department's tort claims. There were 1,048 lawsuits pending, representing damage claims totaling \$981 million. A 1978 American Association of State Highway and Transportation Officials survey reported more than 8,000 tort claims against all State highway agencies totalling \$2.4 billion."<sup>@</sup>

This trend toward increased tort litigation has shown no signs of ceasing, or even decreasing. A research paper presented at the 71st annual meeting of the Transportation Research Board estimated the total number of tort claims levelled at highway agencies during 1990 to be 33,000 to 35,000. The report does not give the total dollar amount of claims, but it does estimate that the total amount of money lost to claims, plus the amount spent researching and defending against the claims, as being more than one-half billion dollars.<sup>(97)</sup>

The increase in claims and awards has also resulted in an increase in the cost of liability insurance, where it was not canceled outright. Deductibles have been raised to multimillion-dollar levels in some cases, and some States have had to self-insure.

Obviously, States would rather spend public funds on proper maintenance of roadways than in paying off tort claims. States should therefore review maintenance and reporting procedures to limit exposure to tort liability. Highway agency employees involved in such activities should be well-informed of the legal implications of their functions.

## **SOURCES OF FUNDING**

One of the major concerns facing highway agencies is obtaining adequate funding for their various programs. While the courts are quick to point out inefficiencies by making judgments against highway agencies, these problems often stem from lack of adequate funds rather than from inattention to standard engineering practices. In many cases, there is simply not enough money available to support all the desired programs.

In recognition of this nationwide problem, Federal funds have been available for several years to assist States under various programs. These funds were in addition to the Federal funding for research and development. A significant Federal program that provided funding for delineation-related activities was the Highway Safety Act of 1973 (23 U.S.C. 151). The Act emphasized improving safety on rural roads, where about two thirds of all severe traffic accidents occur.

Under Section 205, Pavement Marking Demonstration Program of the Highway Safety Act 1973, 100 percent Federal funds were made available for painting centerlines and edgelines on roadways whether they were on the Federal-Aid System or not. Any hard surface roadway was eligible for funding. The Pavement Marking Demonstration Program used Federal funds to encourage wider application of pavement markings. The installation of such roadway markings have clearly reduced fatalities and injury accidents. 23 U.S.C. 120(c) allows 100 percent funding for safety U.S.C. improvements including markings.

In addition to painted centerlines and edgelines, other forms and types of pavement markings were eligible under the program. These included thermoplastic markings and raised pavement markers; markers in advance of railroad crossings; roadside delineators; and school zone, pedestrian crossing, and stop bar markings.

According to the Secretary of Transportation's *1979 Annual Report on Highway Safety Improvement Programs*,<sup>(98)</sup> about 25 percent of Pavement Marking Demonstration Program funds were used for these eligible items.

A significant change was made to the Federal-aid program by the 1982 Surface Transportation Assistance Act and the 1987 Surface Transportation and Uniform Relocation Assistance Act. Federal funds now can be used for refurbishing or replacing traffic signs or markings that have exceeded their service life and are no longer effective.

## **PROCUREMENT PROTECTION**

Standard procedures for procurement of materials have been used for years, often without periodic review. In addition, procurement policies have not been updated to reflect changing conditions. This section discusses some of the aspects of material purchase and use of contractor's forces.

### **Quantity Purchase of Materials**

When purchasing materials, such as paint, thermoplastic, raised pavement markers, or post-mounted delineators, quantity discounts are generally available from suppliers. For example, a one-way retroreflective raised pavement marker might cost \$1.75 per unit when purchased in quantities of 1 to 99. When purchased in lots of 5,000, the unit price may be reduced to about \$1.25, resulting in a \$2,500 savings when purchased in lots of 5,000. Extremely large-scale purchases would reduce the unit cost even more.

Many States negotiate with suppliers so that local highway agencies can buy materials at the quantity prices quoted for the State. This "buying off the State contract" requires an estimate of quantity needed and acceptance of the materials by the State.

Interagency purchases is another method used by State and local highway agencies to obtain lower unit prices. In this case, the State prepares the specifications, tests the materials, and selects the contractor. Local highway agencies then are allowed to buy material directly from the State. There is frequently a small surcharge to cover the State's administrative expenses.

The State of Wisconsin allows city and county highway agencies to purchase materials that are distributed from State warehouses for cost plus a 5 percent surcharge. New York, however, allows local highway agencies to order through the State without surcharge. When the State makes no provisions, local highway agencies can band together to purchase material in bulk quantities.

Even if a small, local highway agency purchases directly from the supplier, it is best to buy materials with a long shelf life in sufficient quantity to obtain the unit discount. Storage problems may arise using this method. Small highway agencies can purchase many years supply of paint (depending on shelf life) to be delivered at specified times throughout that period. Because material may be damaged or may deteriorate in storage, the savings in unit cost must be balanced against the potential waste.

Something else that will affect the cost of materials is their packaging. Small sacks, pails, or cartons may prove easier to handle and store but may cost too much to justify their use. (See Warehousing and Storing of Materials, chapter 4.)

### **Inventory and Recordkeeping**

Good business practice requires maintenance of an inventory of supplies and materials, which requires proper planning and scheduling. Shortages can interfere with scheduled maintenance activities and/or require emergency purchases at

inflated prices. In practice, the anticipated volume of materials is established in budget preparation activities. Unfortunately, the item is often budgeted based on some "rule of thumb," such as last year's use plus a percentage increase. Where good historical records are available as a basis, this practice may suffice.

Estimating future costs accurately based on previous years' use is difficult. In addition, smaller highway budgets encourage highway agencies to rank individual marking projects' importance in order to select affordable options. The benefits from careful planning, scheduling, and balancing the inventory of needed materials will normally offset the effort involved.

### **Use of Model Specifications**

The American Association of State Highway and Transportation Officials, the American Society for Testing of Materials, the Institute of Transportation Engineers, and individual highway agencies have expended a great deal of time and effort to develop specifications for the purchase of various categories of materials and equipment. Model specifications are available for most commonly used delineation devices or components. These models reflect extensive research and field experience and can be easily adapted for local use. Appendix C lists various sources of model specifications.

State highway agencies usually circulate copies of their standard specifications to local highway agencies. This usually saves staff time and usually produces a comprehensive and complete specification. In addition, this practice encourages uniformity of marking practices within the State.

The most critical issue in the preparation of specifications is the choice between a composition (formulation) specification or a functional (performance) specification. This issue is discussed in chapter 4 under Purchase of Materials, page 36.

## Use of Contractors

The use of private contractors for delineation instead of highway agency forces is another significant consideration in the procurement process. Contractors are typically used in the following circumstances:

- Roadway delineation installation is part of a larger project under contract and it is more economic and efficient for the contractor to be responsible for the whole job.
- Installation requires special equipment and staff skills not available within the highway agency.
- The magnitude or immediacy of the work is beyond the resources of the highway agency.

Cost of services is most important in deciding the best course of action. It should be stressed, however, that other factors may play an important role in the decision. For example, some delineation techniques require sophisticated installation procedures in order to perform as expected. Under contract, performance warranties will protect the highway agency against early failures and can be more economical in the long run. Moreover, manufacturers who provide contract installation will probably be better at applying their own product.

However, there is little doubt that State or local highway agency personnel can perform the work cheapest if they have the proper equipment. They are more familiar with the condition and characteristics of the roadways to be marked and often can adapt application procedures to the specific need of an area. It is not unusual for a maintenance crew, for example, to adjust the amount of glass beads applied to provide higher retroreflectivity in a troublesome area. The experience of the field crew is often overlooked at administrative levels; yet, it is a valuable

resource that cannot be purchased under contract.

At a higher planning level, the cost of equipping and staffing internal forces to provide all the necessary installation and maintenance services must be balanced against the cost of using contractors. Mileage of roadways, the time available for marking activities, other maintenance activities that must be accomplished, and the amount of existing staff and equipment must all be considered in the decision-making process.

## COORDINATION OF ACTIVITIES

The activities of other highway agencies and of other departments within the same highway agency need to be coordinated to avoid conflicts. For example, where maintenance is scheduled on a regular basis, such as repainting, a section might accidentally be marked just prior to other work that may destroy the markings.

The installation of long-term delineation, such as raised pavement markers or thermoplastic markings, is justifiable only on the basis of durability, safety, and service life. These benefits are negated if these markings are placed on roadways scheduled for resurfacing. This happens too often, usually from lack of departmental communication. This also occurs when roadway activities of utility companies are not known by the maintenance forces.

There are advantages in scheduling delineation work with other roadwork that requires crew protection. This requires coordination among activities, especially if the other work **is** managed by someone else.

## COST CONSIDERATIONS

Administrators and managers responsible for roadway delineation systems are extremely concerned with the increasing costs of delineation and diminishing budgets. As other programs and functions



compete for available funds, it is vital to justify expenditures in terms of the costs and benefits of planned activities.

Several studies have tried to determine the cost-effectiveness of various delineation techniques.<sup>(29,30)</sup> Other studies have attempted to quantify the benefits from the accident reduction.<sup>""</sup> Still other studies have tried to find ways of reducing the costs of using common materials, equipment, and procedures.<sup>(58)</sup>

It has been hard to predict the costs associated with application of pavement markings. Funds spent by one highway agency are dissimilar to funds used for a similar application by a different highway agency. Not only do costs of materials and labor vary in different regions of the country, but accounting procedures and policies also vary.

To be realistic, cost should be based not only on initial expenditure, but on total cost amortized over the life of the marking. However, because of the numerous site-dependent variables, there is little agreement on the service life of a particular delineation technique.

Also, a problem arises when trying to quantify benefits. Benefits are assigned a dollar value based on accident reduction. Accident reporting systems are upgraded constantly to provide the necessary information for such studies, but so far accident data remains sketchy. It is difficult to identify precisely improvements associated with delineation based on accident data. At best, the figures are only approximations.

It is hoped that Federal Pavement Marking Demonstration Program will provide additional information in determining costs and benefits of delineation systems. When all the projects in this program are documented, better evaluations will be possible. In the meantime, there are statistical analysis techniques available for

use. There are also economic analysis models developed to evaluate the costs and benefits and cost-effectiveness of the individual delineation techniques.

Research has attempted to provide some insight into the effect of delineation on accidents. (See references 22, 29, 30, 41, 99.) The major findings are summarized below.

### **Pavement Markings**

The most common type of delineation is the painted marking. One of the first issues addressed in the research program was the need for pavement markings. Although the need for marking, especially for a centerline, is rarely questioned, there are many miles of low-volume, two-lane roadways without any markings.

Markings reduced accidents approximately 30 percent; the data were significant at the .05 level. If this finding is extrapolated to traffic volumes lower than those observed in the study, centerlines can be cost-effective at ADT volumes as low as 50 vehicles.

Driver behavior studies have shown that adding a centerline to a previously unmarked roadway reduced the roadway's predicted hazard level by almost 50 percent. This implies that the centerline should be used whenever a roadway has a paved surface that will retain a pavement marking and is wide enough to carry two-way traffic.

Although their effectiveness has been questioned, edgelines are generally accepted practice on major roadways. Accident analyses showed that edgelines improved safety, but this major improvement was greater on straight roads than on winding roads. This finding was not expected. It appears to show the importance of stress on driver attentiveness. A driver is less attentive on straight roads and appears to rely on edgelines. On winding roads where a driver is under stress and paying

attention to the driving task, edgelines do not appear to be so vital for guidance.

It can be concluded that edgelines are important in a roadway delineation system and should be used on major roadways wider than 20 feet (6 meters). If traffic safety is the only consideration, an ADT volume of 1,000 vehicles is necessary to make edge lines cost-effective. If other factors are considered, such as reduced costs for shoulder maintenance, edgelines may be justified on roadways having ADT volumes lower than 1,000 vehicles.

The *MUTCD* requires a 3-to-1 gap-to-segment ratio for both centerlines and lanelines. Although this ratio is normally adequate, situations where forward visibility is reduced may require a lower gap-to-segment ratio. In mountainous terrain, or where climatic conditions commonly cause limited visibility, the 3-to-1 ratio should be supplemented by raised pavement markers.

### **Raised Pavement Markers**

Raised pavement markers (RPMs) basically have replaced painted centerlines and lanelines, especially in the Sunbelt States. Typically, four nonretroreflective RPMs and one retroreflective RPM are used in place of each marking segment. In other cases, RPMs are used to show roadway alignment and to supplement existing pavement markings.

Use of RPMs as lanelines reduces the amount of lane changing and discourages encroachments onto adjacent lanes. There is a rumble effect produced by running over the markers. Research has shown that RPMs reduce a vehicle's lateral placement variance and lessen driver stress at night in wet weather.

Accident analysis studies showed that when painted centerlines were replaced with RPMs there was a reduction of approximately 0.05 accidents per million vehicle-miles (0.03 accidents per million vehicle-

kilometers). If an area receives no snow, RPMs are cost beneficial at an ADT volume of 3,000 vehicles. This markers are assumed to have a service life of at least five years and that they cost less than \$4,000 per mile (\$2,500 per kilometer) to install.

Because of the high initial cost of RPMs, especially the snowplowable types, highway agencies have supplemented painted centerlines and lanelines with RPMs every 80 feet (25 meters) to develop an all-weather delineation system at low cost. The cost of such a supplemental system, \$1,000 to \$1,500 per lane mile, (\$620 to \$930 per lane kilometer) is considerably lower than the cost of complete replacement. In the human factors and traffic performance studies, hazards were reduced 30 to 40 percent with this type of treatment.

Traffic performance studies indicated that RPMs are more effective than post-mounted delineators on isolated horizontal curves. RPMs' guidance is near the driver where actual steering is done, though they also provide the long-distance visibility needed to see road alignment changes. RPMs also provide better understanding of the driving situation to the driver than do most forms of supplemental delineation. Research suggests that one-way RPMs along the outside of each driving path are more effective than two-way RPMs on curved roadways. The cost-effectiveness of such an installation depends on the particular site.

### **Post-Mounted Delineators**

Post-mounted delineators (PMDs) of various shapes, colors, and retroreflective characteristics are used widely throughout the United States. PMDs are especially effective at night and in adverse weather when standard markings are covered by ice, snow, or water. They provide the driver with a preview of roadway direction, but do not provide much steering information because of their offset location.

Accident rates are significantly lower where PMDs are used. A reduction of approximately 1 accident per million vehicle-miles (0.6 accidents per million vehicle-kilometers) has been demonstrated. If safety is the only benefit considered, PMDs are cost-effective (with any reasonable cost-to-life ratio) for ADT volumes exceeding 1,000 vehicles. In many cases, depending on local specifics, such treatments can be justified for ADT volumes as low as 500 vehicles.

As with RPMs, the selective use of PMDs are effective for all weather conditions. Driver performance improves significantly with the use of PMDs on horizontal curves. Accident analyses demonstrate a lower accident rate at isolated horizontal curves where PMDs supplemented the standard painted markings. However, the sample size was too small to make a definite conclusion.

### **Signing**

The use of signing, such as Chevron Alignment, large arrow, and turn and curve signs, to supplement other delineation devices has been used mostly for those roadway areas judged to be particularly hazardous or high-accident locations. They are used generally to inform the driver of a potentially dangerous condition that may not be obvious to casual observation.

A manual on treatment of high-accident locations for the Missouri Highway and Transportation Department collated the results of a variety of accident studies. The manual derives accident reduction rates for a variety of countermeasure treatments, including the use of general warning and regulatory signing.<sup>(100)</sup>

The data presented in the manual demonstrate that accident rates can be reduced by about 30 percent over the no-signing condition when using warning signs in advance of curves. An accident reduction rate of up to 40 percent can reasonably be

expected when warning signs are used in advance of rural intersections.

The manual does not derive cost-effectiveness relationships in terms of ADT. However, warning signs have relatively low installation costs, simple maintenance, and require replacement infrequently. From these factors it would appear that the use of warning signs should be cost-effective wherever their use is appropriate. The proper areas where warning signs should be used are discussed in chapter 10.

### **Conditions for Cost-Effective Applications**

The most cost-effective delineation system will be achieved by carefully considering the delineation variables and applying good engineering judgement for each individual project. In other words, it is important to consider all aspects of an area to be delineated, not just the roadway type or immediate surroundings.

For example, if a horizontal curve on a rural two-lane road has been identified as a high-accident location, many factors must be considered before a delineation treatment is determined. One of the first considerations in this case is the type of accidents that occur. If, for example, the majority of the accidents are run-off-the-road type accidents, and they occur mostly at night during rainy weather, then it is obvious that the existing delineation probably is not bright enough for these adverse visibility conditions. RPMs may be an effective solution in areas where winter maintenance activities are not a primary operation. In snowy areas, PMDs or warning signs, such as Chevron Alignment, may be the most cost-effective technique.

The benefit-cost analysis technique presented in appendix A is a quantitative method for examining delineation alternatives to obtain cost-effectiveness. However, the key to optimizing benefit-cost ratio for different types of delineation projects lies in

combining the cost factors with a thorough application of engineering judgment. Only thoughtful engineering judgement and common sense will ensure accurate estimates for service lives to be used in the benefit-cost calculations. The basic treatment of delineation variables in chapter 3 gives an overview of how these and other variables must be considered for delineation projects. All pertinent variables must be considered to achieve the best durability for delineation, and hence the highest level of cost-effectiveness.

### **INSPECTION OF PAVEMENT MARKING PROJECTS**

One of the most effective methods of decreasing tort liability risk is a comprehensive program of pavement marking inspection. This was discussed somewhat in chapter 11. In this chapter we will focus on the administrative portion of implementing such a program.

#### **Inspector Training and Certification**

Each State should have its own program for certifying inspectors. This is often done through a series of training sessions and workshops for inspectors about the important aspects of inspecting pavement markings. Some organizations, such as the American Traffic Safety Services Association (ATSSA) have developed training videotapes to aid in this effort. Some States, such as Ohio, have developed their own videotapes, which are more specific to in-State concerns.

#### **Sources of Sample Specifications**

In addition, a number of organizations have developed sample composition and performance specifications for pavement marking materials. These can be useful to State and local highway agencies in developing their own standards. Often, a State will adopt one set or a combination of the specifications produced by these independent sources and modify them for their own purposes. The local highway

agencies can then adopt the State standards, which more closely apply to the conditions experienced within the local jurisdictions. Some of the organizations that produce specifications are the American Society for Testing of Materials (ASTM), American Association of State and Highway Transportation Officials (AASHTO), Federal Highway Administration (FHWA), General Services Administration (GSA).

Information on these and other highway agencies that supply sample specifications can be found in appendix C.